The Total Solar Eclipse of September 21.

By Dr. A. C. D. CROMMELIN.

THERE are at present in the Saros Cycle two series of eclipses which have unusual length of totality; one including those of 1865, 1883, 1901, 1919, the other including the great Indian eclipse of 1868, in which the spectroscope was first applied to the prominences; also those of 1886 (West Indies) and 1904 (Pacific). The forthcoming eclipse, September 21, being three Saroses after that of 1868, is in nearly the same longitude, but has moved southward, the only land stations available being the Maldives, Christmas Island, and Australia.

The Maldives have the disadvantages of a rather low sun, some difficulty of access, owing to the reefs surrounding the islands, probability of high wind, together with a poor health record for European visitors; they are, however, being occupied by Mr. Evershed. Christmas Island lies in the longitude of maximum totality (6 minutes), but being near the northern limit of totality it will enjoy only 3¾ minutes. This is, however, amply long enough for the programme planned. The station is occupied by Messrs. Jones and Melotte from Greenwich, their equipment consisting of the 13-inch astrographic equatorial, on a mounting specially constructed for the low latitude of the station. When the same instrument was used in Brazil in 1919 the star-images were diffused, owing probably to slight warping of the cœlostat mirror by the heat of the sun before totality. The unsuitability of the cœlostat had been foreseen, but the short interval between the armistice and the departure of the expedition made it impossible to provide an equatorial mounting.

On the present occasion it is desired to secure a completely satisfactory check on the 1919 results; these tended to confirm the amount of shift of light by the sun's gravitation predicted by Einstein; the difference in the results given by the two instruments in Brazil was, however, too large to permit the results to be taken as absolutely final, and a further test is desirable. The star-field at this totality is, unfortunately, much less favourable than that in 1919, which was probably the field containing the largest number of bright stars close to the ecliptic. There are, however, a fair number of stars of the eighth magnitude or brighter in the present field, and it is hoped that these may be photographed with somewhat longer exposures than those given before. The corona will probably be of the "Minimum" type, with little extension near the poles; this should enable stars fairly near the sun, which will have a large factor of shift, to be photographed.

Christmas Island is occupied by a Phosphate Company, under Scottish management, which has given great assistance to the expedition in transporting their baggage, in erecting huts, providing workmen, etc. Reports received in July stated that the adjustment of the instruments was complete, but that the weather during May had been very wet, and little observing was possible; check plates of the eclipse field had, however, been secured. The rainy season was, however, nearly at an end, and it was hoped that more work would shortly be possible; in addition to the eclipse programme it was planned to take a series of photometric plates, to connect the magnitude scales of the northern and southern hemispheres. Profs. Freundlich and Einstein also arranged to observe from Christmas Island, their programme being much the same as that of the British observers.

The station on the coast of West Australia has a high sun, long totality, and excellent weather prospects; but it is difficult of access, it being necessary to anchor some miles out, and land in small boats through surf. Several parties are there; that with the largest equipment is from the Lick Observatory, under Prof. Campbell. This party also makes the Einstein problem the chief item of the programme. To avoid a long stay at the eclipse camp the check plates were taken at Fiji on the voyage out. Other parties at this station are from Canada and from Perth (Australia).

The observatories of Adelaide, Melbourne, and Sydney are sending expeditions to stations in Central Australia and in Queensland. The weather prospects are good at both, but the sun in Queensland is rather low. They are understood to be attempting the Einstein problem, in addition to the older eclipse work of photography of the corona and its spectrum.

There is every reason to hope for success at some of the stations; fine weather at all of them should lead to results of a decisive character on the Einstein problem. The results will not be available for some time, as the plates will not be measured till the return of the different parties. They will, however, be developed, *in situ*, which will permit a good idea of their character to be formed. In this connexion it may be noted that there is no cable to Christmas Island, but it is expected that a Dutch man-of-war will be there, which might send a wireless message to Java.

The Deflection of Light in a Gravitational Field.

By HERBERT DINGLE.

FROM an experimental point of view, Einstein's general theory of relativity is at present in an ambiguous position. It is well known that there are three conceivable tests between its conclusions and those of the traditional ideas which it attempts to displace. With regard to the first of these—the movement of the perihelion position of Mercury—the success of the theory is decidedly impressive; all the more so, perhaps, because the result was stumbled upon, as it were, involuntarily. In seeking first the gravitational field of the sun, Einstein found the true orbit of Mercury added unto him. On the other hand, the predicted displacement of the solar spectrum lines certainly conjures up a serious obstacle. The evidence, it is true, is contradictory, but, such as it is, it seems to show a balance against the existence of the displacement. The extreme difficulty and complexity of the experimental work must, nevertheless, be borne in mind. Perhaps it is scarcely possible, in the present state of our knowledge and experimental equipment, to obtain a definite solution of the problem. The third test—concerning the deflection of light in a gravitational field—accordingly becomes of very considerable importance, and to many minds constitutes the deciding factor in their judgment of the theory.

Consequently, the chief item in the programme of the Royal Astronomical Society's expedition to Christmas Island, on the occasion of the total solar eclipse of September 21, will be the investigation of this particular problem. It will be remembered that the original test, on May 29, 1919, was considered by the observers and a large number of others to give conclusive evidence in favour of the relativity theory: it was this result, in fact, that directed general attention to the theory, and made Einstein, for a brief spell, a noteworthy figure in public esteem. The interpretation of the observations, however, has been subjected to various criticisms. A refracting atmosphere of the sun has been proposed. Attempts have been made to explain the effect as a result of terrestrial atmospheric refraction arising from a temperature gradient across the boundary of the moon's shadow-cone. Still more serious is the evidence of the mutual displacement of adjacent photographic images: the question arises whether the observed positions of the star images might not be, to some extent, dependent on the intensity of the coronal light. It must be admitted that the criticisms have been well met. Nevertheless, so fundamentally important a matter can scarcely be regarded as finally settled by a single set of observations, and the repetition which is about to take place is anything but a superfluous confirmation of previous knowledge.

It will be opportune at this time to recall the nature of the problem, and see wherein lies the difference between the traditional and the relativity conceptions which makes the prospective test possible. From the time of Newton until quite recently, gravitation has been looked upon as an essential property of matter—as characteristic as the property of inertia. Whenever we find matter showing the unmistakable effects of inertia, we find also evidence of gravitational influence. The universality of these twin phenomena has so impressed physicists that they have come to look upon them as the fundamental properties of matter. Matter is, by definition, that which has inertia and exerts gravitational attraction. Nevertheless, it is well to point out that inertia and gravitation are not the properties by which matter is generally recognised. With regard to most of the matter in the universe, there is no evidence that they exist. We announce the presence of matter when we *see* it: in other words, matter everywhere has the power of emitting or absorbing light—or, more generally, radiation. We see light, and we deduce a star; the light fluctuates, and we deduce absorbing matter. If, according to the true scientific method, we establish our fundamental conceptions on the groundwork of pure observation, we must place the power to radiate and absorb light at least as deep down in the nature of matter as the inertial-gravitational property. The recognition of either property is universally accepted as evidence of the existence of matter.

The difference with which we are concerned between the traditional and the relativistic conceptions may be expressed in this way: that whereas the older view gives no *a priori* indication of a relation between the two fundamental material influences, gravitation and light, it is an essential condition of the relativity theory that such a relation exists. A large and valuable system of thought has been built up—mainly during the last hundred years—in which radiation and gravitation are completely independent. Radiation submits to analysis and invites correlation with other physical phenomena; gravitation stands inaccessibly apart. The complex organism of electromagnetism, embracing as it does radiation, the æther, electricity, magnetism, the atom—even inertia (for radiation possesses inertia)—seems capable of assimilating the whole of physics—except gravitation. Matter appears to be the source of two streams of phenomena, one summarised in electromagnetism and the other in gravitation, and between them there is a great gulf fixed. The completeness of the duality lies, of course, only in the conceptions. Experimental evidence of a bridge across the gulf might have arisen at any time. Standing now on the bridge, it seems a little strange that it was not sought before. Inertia, in submitting to the electromagnetic scheme, might carry with it the gravitational property with which, in material bodies, it is always associated, and the electromagnetic inertia of light might be accompanied by a proportionate power to exert and respond to gravitational influence. There is no reason, according to pre-relativity physics, why it should, but neither is there any reason why it should not. The impotence of the electromagnetic theory even to suggest the more probable of the alternatives is its main defect.

There is no such ambiguity in the utterances of the relativity theory. Here gravitation—as a physical existence giving rise to a gravitational field—is ignored: the field alone is considered. The seat of the phenomenon is not sought in the secret nature of matter; it is sought in the space surrounding matter, and is, in fact, regarded as a property of that space—or, rather, space-time. The justification for this view is found in the facts, first, that the evidence for the existence of gravitation is the observed acceleration of one body in the neighbourhood of another; and, second, that the acceleration produced by one body in another is independent of every property of the latter except its position relative to the former. Now a phenomenon manifesting itself as an acceleration (involving the dimensions of space and time only) and producing effects depending only on position, can be submitted to a geometrical treatment, provided that the dimension of time is added to those of space. Instead of speaking of the curved paths of bodies in a homogeneous space-time, we can speak of the straight paths of bodies in a heterogeneous space-time. The same phenomenon is indicated by both statements. Expressed in this way, it seems as though there could be no difference between the two views, except that one might be more convenient than the other. Considered from a physical point of view, however, the difference between them is fundamental, and issues into the three experimental tests referred to. The deflection of light in a gravitational field follows naturally, if gravitation is attributed to the heterogeneity of space-time. Any entity—whether light or matter—pursuing its natural path, will appear to change the character of its motion when the space-time through which it travels departs from the simple Euclidean type. It does not matter what the moving thing is; all that counts is the region through which it moves. The dilemma of the older theory does not exist from the relativistic point of view: light must be deflected or the theory must be abandoned.

Fortunately, the amount of the deflection which relativity demands is measurably different from that which the electromagnetic theory allows. According to the relativity theory, a ray of light which just clears the sun's limb should suffer a deviation of about 1″·75; according to the other view, the deviation should be either half of this or nothing at all. It is this difference that makes possible the test which is about to be applied. On September 21 the sun will be leaving the constellation Virgo—very close to the celestial equator. The position is not so favourable with respect to neighbouring bright stars as was that of May 29, 1919, when the original test was made. On the other hand, the experience and criticisms arising from the previous attempt are available for the guidance of the present observers, and, granted favourable conditions, there seems to be no reason why the result should not become decisive.

The British Association at Hull.

YORKSHIRE hospitality is proverbial, and it has been very pleasantly manifested during the meeting of the British Association just concluded at Hull. The citizens have in many ways shown themselves to be proud to entertain the Association, and the facilities they have offered to the members have been exceptionally helpful. Each member was provided with a badge, and this was not only a free pass on the quick and convenient tramway system of the city, but also secured personal guidance and interest from citizens in the streets or in vehicles of any kind. It would be impossible for a city to show greater interest in its visitors or to do more to make their sojourn pleasant, and the many attentions have been much appreciated, particularly by officers and other active members of sections who usually have not the time to search for all the amenities which a place of meeting may afford. A number of free luncheons have been provided, and when the days' meetings have been over tea has been served in the writing-room at the Guildhall, and has been found both grateful and comforting to the members. For these and other unusual attentions the Association is no doubt chiefly indebted to the local secretary, Mr. T. Sheppard, curator of the Hull Museums, but with him is associated the town clerk, Mr. H. A. Learoyd, and the generous hospitality would not have been possible without the active interest and support afforded by the Corporation and people of the city. The Handbook to Hull and the East Riding of Yorkshire, edited by Mr. Sheppard and presented to each member, is a volume of permanent value, and as it will be on sale for the low price of five shillings we propose to publish a separate notice of it in an early issue.

At the meeting of the general committee at which the report of the council was presented, a resolution was passed conveying to Prof. Turner the most cordial thanks of the Association for the valuable services he has rendered to science in general and the Association in particular during his nine years' work as one of the general secretaries. In its report the council stated that it had received with great regret Prof. Turner's intimation that he would not be able to attend a meeting in Canada in 1924. Prof. Turner himself pointed out that it was desirable, on various grounds, that his successor should have experience of the working of an annual meeting at home before taking part in one overseas, and he therefore placed his office at the disposal of the general committee as from the Hull meeting. The council and the Association owe a deep debt of gratitude to Prof. Turner for his unremitting care for the interests of the Association as general secretary since 1913, and therefore during a time of exceptional difficulty, including as it has the Australian meeting, the war, the revival of the annual meetings since the war, and the period when, on the death of the late general treasurer and assistant treasurer in 1920, he acted for some months as treasurer in addition to his other work.

Mr. F. E. Smith, director of scientific research at the Admiralty, and secretary of the Physical Society, accepted the invitation of the council to be nominated as Prof. Turner's successor, and the general committee unanimously voted his appointment to the office of general secretary of the Association. The three new members of the council appointed by the general committee are Mr. E. N. Fallaize, Dr. C. S. Myers, and Prof. A. Smithells.

Next year's meeting will be at Liverpool with Sir Ernest Rutherford as president, and in the following year the place of meeting will be Toronto. The invitation to Canada was conveyed by Prof. J. C. Fields and Prof. J. C. McLennan, and it was announced that a grant of about 11,000*l.* would be available towards meeting the travelling and other expenses of visiting members.

SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS.

EQUAL PAY TO MEN AND WOMEN FOR EQUAL WORK.

IN Prof. F. Y. Edgeworth's address to Section F (Economics) the question whether the wages of men and women should be determined on the same principles—in particular, through universal unrestricted competition—was discussed on purely economic grounds. Notwithstanding the general presumption in favour of *laisser faire*, it is maintained that some regulation is required for desperate competition tending to the